Vector Problems
General Information

• Vectors act independently
• Example: A boat with a velocity of 20 m/s east and a 7 m/s current flowing south.
  – The boat travels 20 m east every second
  – The river flows south 7 m each second
  – If the boat were not going east it would be carried by the current in the same way it gets carried by the current when it is drifting
Vector Addition Reminders

- Vectors are drawn as arrows
- Always combine vectors tail to head
- You can move a vector so long as you don’t change its magnitude or direction
- The resultant is drawn from the tail of the first vector to the head of the last vector
- The angle you are looking at is the angle formed by the tail of the first vector and the tail of the resultant
Vector Mathematics

- Always draw a diagram
- Use the Pythagorean Theorem for the magnitude of the resultant
- Use tangent for the size of the angle
- Make sure you accurately describe the exact direction of the resultant
- Resultants have two parts
  - Magnitude with unit
  - Angle with reference degree
1. A boat travels west at a speed of 24 m/s across a river that is flowing south at 9 m/s. What is the resultant velocity of the boat?
Vector Diagram

24 m/s

9 m/s

X
Magnitude Calculation

\[ c = \sqrt{24^2 + 9^2} = \sqrt{576 + 81} = \sqrt{657} = 25.6 \]
Angle Calculation

\[
\tan^{-1} = \frac{9}{24} = 0.375 = 20.6^\circ
\]
Final Answer

25.6 m/s @ 249.4°
2. A plane flies south at 650 mph with a cross wind towards the east at 130 mph. What is the resultant velocity of the plane?
Vector Diagram

650 mph

130 mph

X
Magnitude Calculation

\[ c = \sqrt{650^2 + 130^2} = \sqrt{422500 + 16900} = \sqrt{439400} = 663 \]
Angle Calculation

\[ \tan^{-1} \left( \frac{130}{650} \right) = 0.2 = 11.3° \]
Final Answer

662.9 mph @ 169°
3. An airplane flying east at 310 m/s has a 45 m/s tailwind. What is the resultant velocity of the plane?
Vector Diagram

310 m/s

45 m/s
Magnitude Calculation

\[ c = 310 + 45 = 355 \]
Angle Calculation

Everything is headed east
Final Answer

355 m/s @ 90°
4. The Antarctic expedition drives their snowmobiles 185 miles south from their camp. Then they turn and drive 70 miles west. Now it is time to return to camp. In what direction must they drive and will they make it on 190 miles worth of gas?
Vector Diagram

- Note that this is a special case where the resultant vector appears to point backwards.
- This is because that is the path they will need to take back to their base.
Magnitude Calculation

\[ c = \sqrt{185^2 + 70^2} = \sqrt{34225 + 4900} = \sqrt{39125} = 198 \]
Angle Calculation

\[ \tan^{-1} = \frac{185}{70} = 2.64 = 69.3^\circ \]
Final Answer

20.8° & No, they will have to walk 8 miles
5. Tarzan is swimming east at 2.4 m/s across a river that is 1660 meters wide and flows north at 5.2 m/s.
Magnitude Calculation

\[ c = \sqrt{2.4^2 + 5.2^2} = \sqrt{5.76 + 27.04} = \sqrt{32.8} = 5.73 \]
Angle Calculation

\[ \tan^{-1} \left( \frac{5.2}{2.4} \right) = 2.17 = 65.2^\circ \]
Final Answer

5.73 m/s @ 24.8°
B. How long will it take him to cross the river?

- **Data**
  - \( d = 1660 \text{ m} \)
  - \( v_a = 2.4 \text{ m/s} \)

- **Equation**
  - \( t = d \div v_a \)

- **Math**
  - \( t = 1660 \div 2.4 \)

- **Answer**
  - \( t = 692 \text{ s} \)
C. How far downstream will he end up?

- **Data**
  - $t = 692 \text{ s}$
  - $v_a = 5.2 \text{ m/s}$

- **Equation**
  - $d = v_a \times t$

- **Math**
  - $d = 692 \times 5.2$
  - $d = 3600 \text{ m}$

- **Answer**
  - (or about 2.5 miles)